2005

C2IEDM for the GIG: A Tutorial

Blais, Curtis L.

Command and Control Information Exchange Data Model (C2IEDM) Tutorial, (with Chuck Turnitsa, ODU/VMASC), Spring Simulation Interoperability Workshop, San Diego CA, 3 April 2005
http://hdl.handle.net/10945/36560

C2IEDM for the GIG: A Tutorial

Andreas Tolk
Charles Turnitsa
Old Dominion University
VMASC
atolk@odu.edu
cturnits@odu.edu

Curtis Blais
Naval Postgraduate School
MOVES Institute
clblais@nps.edu

Introduction

- Purpose
  - Educate about the C2IEDM
  - Show how its components work to show a very clear view of the Battle Space
- Scope
  - Overview, Overall Structure, Independent Entities
  - Introduce key areas, give some examples of their use
- Tutorial Objectives
  - Clear understanding of the Model
  - View of how it can serve as an Operational Vocabulary

The Challenge

This is the GIG

- Composable Services – Service Oriented Architecture (SOA)
  - Functionality in Services
  - System Functionality composed from Service Functionality
- Central questions
  - How can we make sure that current services talk with each other unambiguously
  - How can we make sure that current services talk with future services unambiguously

The Proposal

- Common Reference Model
  - Unambiguous definition of entities and their relations
  - Information Exchange Data Model
    - Not to replace the interior model
    - Not to be used as the common enterprise wide data model
- Requirements/Constraints
  - Define current state of the art (messages, data replication, etc.)
  - Extensible to future solutions
- Is there such a model?

This is Name Space Management

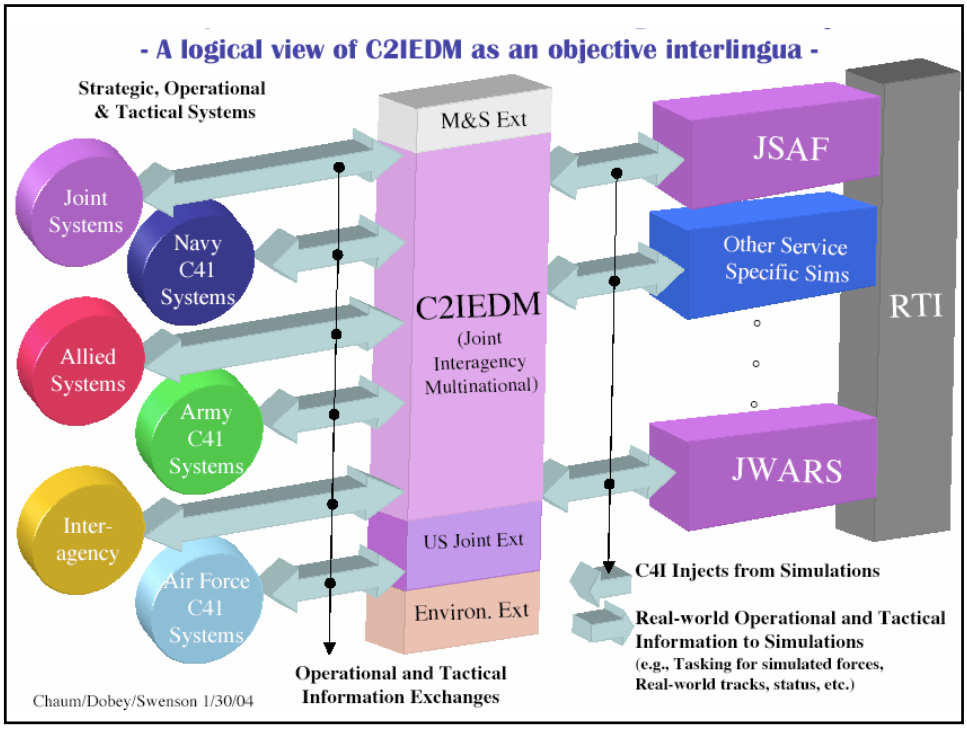
History of C2IEDM

- **1978**: NATO Long-Term Defense Plan (LTDP) Task Force on Command and Control (C2)
- **1980**: Army/Allied Tactical Command and Control Information System (ATCCIS) Permanent Working Group (APWG)
- **1998**: Multilateral Interoperability Program (MIP) replaces Battlefield Interoperability Program (BIP) and Quadrilateral Interoperability Program (QIP)
- **2002**: Merging ATCCIS and MIP, new name for the data model: Land Command and Control Information Exchange Data Model (LC2IEDM)
- **2003**: Name changed to Command and Control Information Exchange Data Model (C2IEDM)
- **2004**: Current version Generic Hub 6.1on website http://www.mip-site.org

MIP/C2IEDM Organization Members/Systems

FULL MEMBERS		ASSOCIATE MEMBERS			
CA	LFC2IS	AS	JCCS, BCSS	RO	
DA	DACCIS	AU	PHOENIX	SI	
FR	SICF, SIR	BE	SICBEL	SW	IS MARK SLB
GE	HEROS-2/1	CZ	GF-TCCS	TU	TKKBS
IT	SIACCON	FI		AFNORTH	
NL	ISIS	GR	HARCCIS	ACT	BiSC AIS
NO	NORTaC/NORCCIS	HU	HAVIR		
SP	SIMACET	LH			
UK	ATacCS/ComBAT	PL	SZAFRAN		
US	MCS (L)	PO	SICCE		

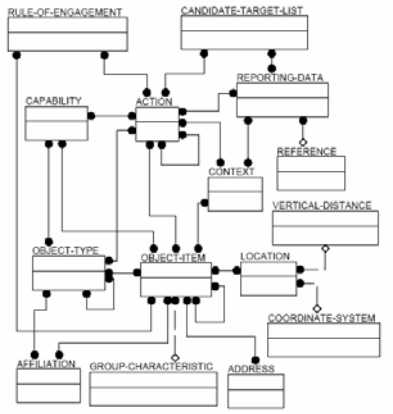
176 Messages
1500 Data Def.



What is the C2IEDM?

- Command and Control Information Exchange Data Model
- Common specification for C2 data to be exchanged
- Expected to be compliant with NATO Level 5 System Interconnection
  - Automated Exchange of Data
  - User Imposed Constraints
  - Connecting C2IS databases

What is the C2IEDM?



- As a hub, the C2IEDM was designed to be extended
- There are over 190 different entities
- 15 of those entities are independent, the rest are dependent
- The two most important trees are those of Object and Action

What is the C2IEDM?

- Documentation is presented through the view of using IDEF1X notation
- **I**ntegrated **DEF**inition (**IDEF**) method of presenting entity-relationship data
  - http://www.idef.com/IDEF1X.html

attribute (FK)	**Foreign Key** Primary key of another entity contributed by a relationship
role.name.attribute (FK)	**Role Name** New name for a foreign key connoting its use.
attribute (AKn)	**Alternate Key** Alternate unique identifier of the entity
attribute (IEn)	**Inversion Entry** Non-unique access identifier of the entity
group.{c1,c2,c3}	**Group Attribute** Attribute is a group containing the listed constituents.
attribute{fk1,fk2,fk3}(FK)	**Unified Foreign Key** Listed foreign keys are unified to a single foreign key attribute

What is the C2IEDM?

- A number of different notations could have been used
  - UML
  - ER notation

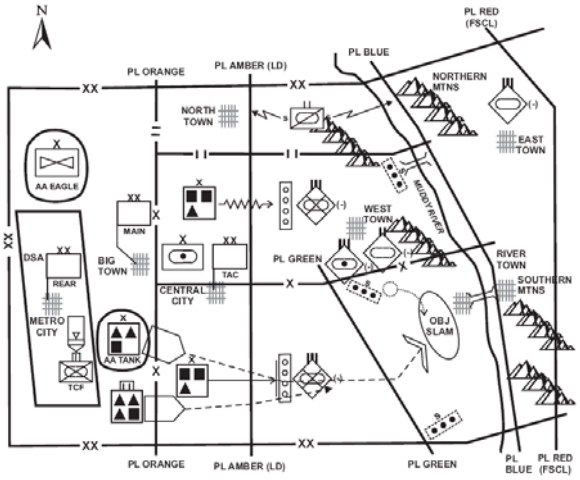
Crucial to realize that although the C2IEDM is based on Entity-Relationship ideas

IT IS NOT A RELATIONAL DATABASE!

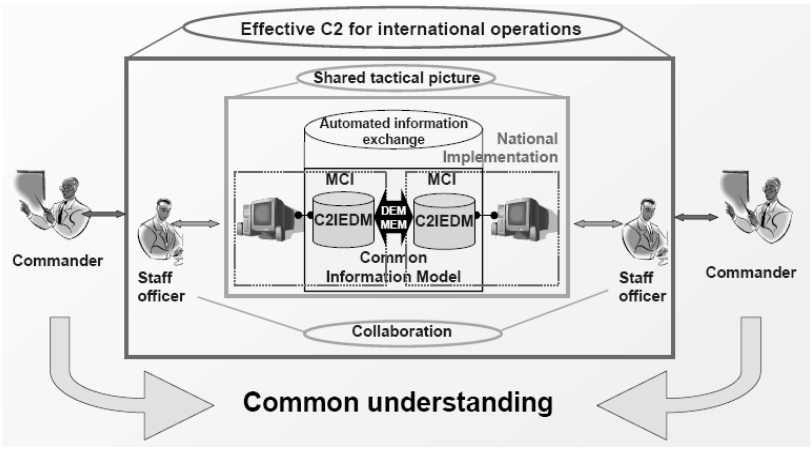
What is the C2IEDM?

- A valuable view as to what the C2IEDM is and how it can be used can be seen in the current C2IEDM/ CROM work being done by ACS
  (see summary for reference)
- CROM (**C**4I-M&S **R**eference **O**bject **M**odel) exists to bridge the connection from C4I systems to M&S systems
- Based on the **entities and relationships** of the C2IEDM

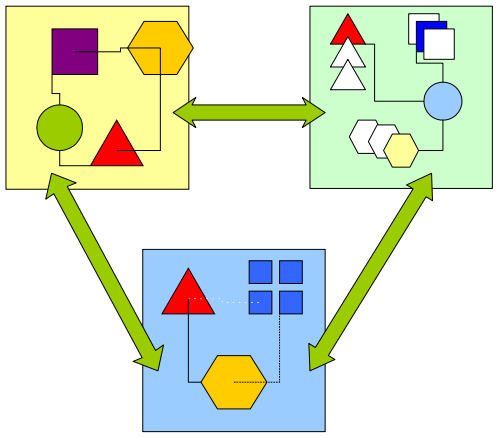
Purpose:
Describing the Battle Space



Purpose:
Connecting C2IS Databases



Purpose:
Common Operational Vocabulary

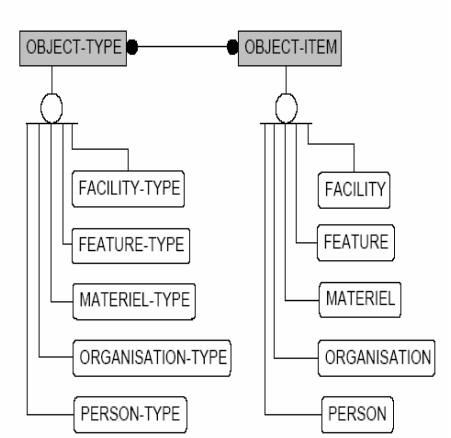


Overall Structure:
Relational Model

- As stated, one of the purposes of the C2IEDM is in exchanging information, about Objects and Events of the Battle Space, between C2IS data systems
- To accomplish this, the model must have a very clear idea of what these Objects and Events are, and how to define and represent them
- The two main entities that satisfy this are the Object Tree and the Action Tree
- The entities comprising these two trees are related to each other and other defining entities through association relationships

Overall Structure: Objects and the Object Tree

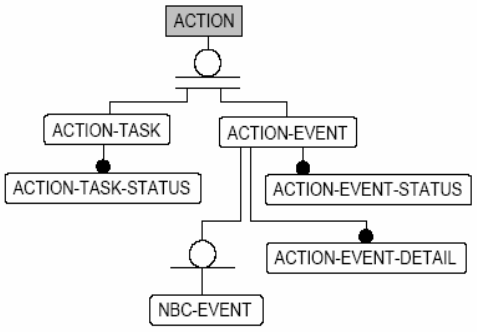
- Objects – Type and Item
- Defined in terms of Type and Item
  - Type gives Class Definitions
  - Item gives Instance Definitions
- Five main types of Object
  - Person
  - Organisation
  - Materiel
  - Feature
  - Facility



Overall Structure: Actions and the Action Tree

- Actions – Task and Event
- Tasks are directed actions that an Entity (Object) can undertake
- Events are actions external to perceiving Entities

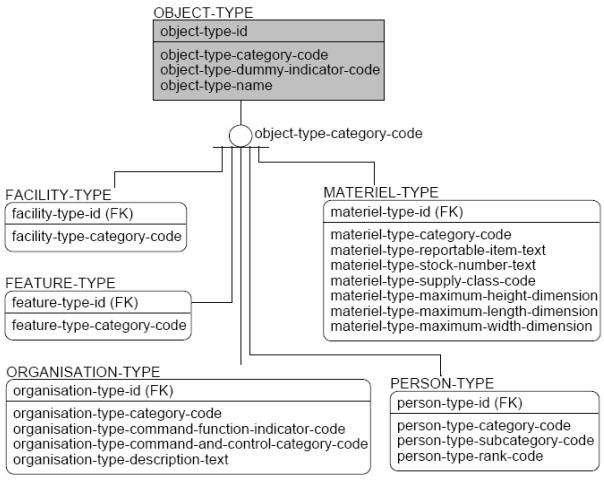
Action Subtype Structure



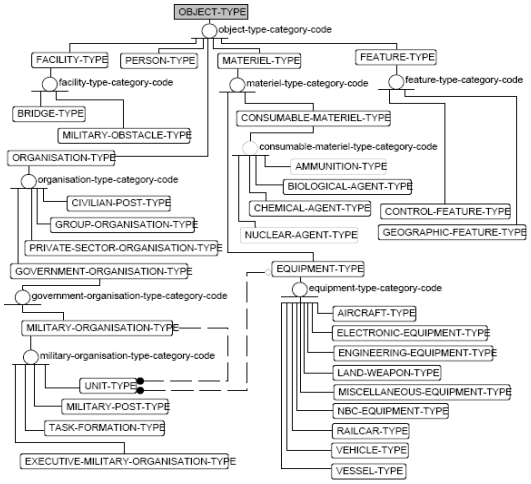
The Object Tree

People, Places, Things
And their Properties

Building Blocks of the Object Tree: OBJECT_TYPE

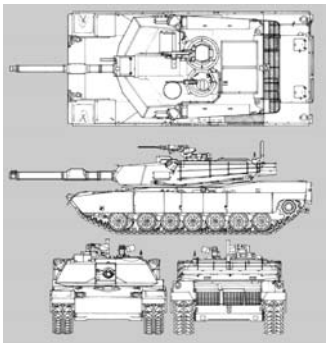


Building Blocks of the Object Tree: OBJECT_TYPE



Building Blocks of the Object Tree: OBJECT_TYPE

- Five basic sub-trees
- Captures the basic “class” specific data that are archetypical to the class of thing being designed
- Example: M1A1 Abrams MBT
  - Physical parameters
  - Class specific data
  - No organizational data
  - No location data



Building Blocks of the Object Tree: OBJECT_TYPE

OBJECT_TYPE

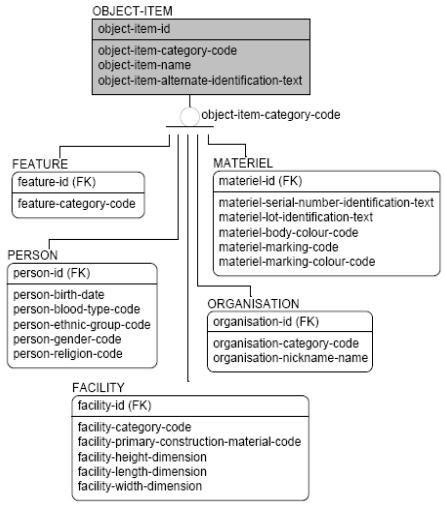
MATERIAL_TYPE

EQUIPMENT_TYPE

LAND_WEAPON_TYPE

land-weapon-type-id	land-weapon-type-category-code	land-weapon-type–subcategory-code	land-weapon-type-calibre-text	land-weapon-type-fire-guidance-indicator-code
801101	Field artillery	Howitzer	155 MM	No
801102	Tank	Battle tank, medium	120 MM	No
801103	Not otherwise specified	Armoured infantry fighting/combat vehicle	30 MM	No

Building Blocks of the Object Tree: OBJECT_ITEM



Building Blocks of the Object Tree: OBJECT_ITEM

- Same sub-trees as OBJECT_TYPE
- Provides for the data required for identifying a specific instance
- Associates with OBJECT_TYPE for class data
  - Location
  - Status
  - ID
  - Unit

Building Blocks of the Object Tree: OBJECT_ITEM

OBJECT-ITEM

object-item-id	object-item-category code	object-item-name	object-item-alternate-identification-text
78128	ORGANISATION	1 Bn 2 (US) Inf Bde	—
3051	ORGANISATION	— [Null: Enemy unit has been observed but not identified]	—
57	FEATURE	Rhone River	—
77709	FEATURE	Task Force Blue Goose FSCL [Fire Support Coordination Line]	—
66499	PERSON	General Smith	—
4311	FACILITY	Blackbush Airfield	—
384753	FACILITY	MF432 [minefield]	—
9447	FACILITY	BFO-1210 [obstacle]	—
102	FACILITY	DIVISION TRUNK SYSTEM	—
5411334	FACILITY	Kharman Harbour	—
12950	MATERIEL	M-8986-YT [vehicle]	—

Supporting Structure for the Object Tree

- Actual Objects? Not necessarily
  - Networks are a type of FACILITY
  - Control Features are a type of FEATURE
  - Visibility as a type of FEATURE
- Multiple Instances of an Item are linked to a Type through the HOLDING association
- TO&E is shown through the ORGANISATION_MATERIAL_ASSOCIATION

Objects in Motion STATUS,CAPABILITY, and ACTION

- All OBJECT_ITEMS have the capability to have their status reported on
  - Under Orders; Damaged; Loaded etc
- All OBJECT_ITEM associations have the capability to have their status reported on
  - Embarkation/Disembarkation; Join a Unit/Convoy
- Locations (point and relative) can be associated with OBJECT_ITEMs

Objects in Motion
STATUS, CAPABILITY, and ACTION

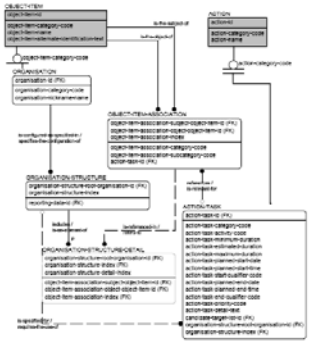
- The ability for objects to perform certain tasks is identified through the CAPABILITY entity
  - OBJECT_TYPE or OBJECT_ITEM

CAPABILITY

capability-id	capability-category-code	capability-subcategory-code	capability-day-night-code	capability-unit-of-measure
567003	ENGINEERING-CAPABILITY	Construction time	Night	Hour
100369	FIRE-CAPABILITY	Maximum range	—	Kilometre
120457	Humanitarian aid and assistance capability	Assistance, bedding	—	Each
340978	Maintenance capability	Maintenance station count	—	Each
380233	Medical capability	Bed Count	—	Each
403134	Military load classification	Military load classification - one-way tracked	—	Each
534222	MISSION-CAPABILITY	—	—	Each
124773	MOBILITY-CAPABILITY	Planning speed	Day and night	Kilometre(s) per hour
100348	MOBILITY-CAPABILITY	Maximum speed	Day	Kilometre(s) per hour
100349	MOBILITY-CAPABILITY	Maximum speed	Day	Kilometre(s) per hour
120345	Obstacle crossing capability	Maximum fording depth	Day	Metre
120346	Obstacle crossing capability	Maximum side slope angle	Day	Degree
134553	Transport capability	Sitting persons count	Day	Each
567778	Transport capability	Pallet count	—	Each
223335	Water delivery capability	Bulk liquid	—	Litre(s) per hour

Objects in Motion
STATUS,CAPABILITY, and ACTION

- Objects are given potential planning, or have their activity reported on by being linked, through association, to the Action tree



The Action Tree

Move, Shoot,
Look, Communicate

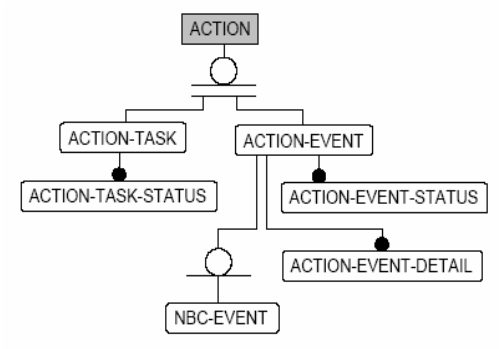
ACTION

- Represents activity in the model: *something carries out an activity to affect something at some time*
- Includes mechanisms for specifying:
  - Items or classes as resources and objectives for activity
  - Recording effects of activity
  - Classifying activities as planned tasks or unplanned events
  - Keeping status of activities
  - Relating activities to each other functionally and temporally

Overall Structure: Actions and the Action Tree

- Actions – Task and Event
- Tasks are directed actions that an Entity (Object) can undertake
- Events are actions external to perceiving Entities

Action Subtype Structure



ACTION Subtype Structure

- ACTION-TASK: actions typically found in plans, orders, and requests
- ACTION-EVENT: an incident, phenomenon, or occasion that has occurred or is occurring but for which planning is not known
- Status entities (ACTION-TASK-STATUS and ACTION-EVENT-STATUS) allow progress of activities to be recorded
- NBC-EVENT and ACTION-EVENT-DETAIL are associated with ACTION-EVENT to handle specialized data requirements

ACTION-TASK

- Example: Planned times for ACTIONs that are part of an operational order

Label	Resource	Activity	Objective
Action 1	52 Inf Div	Defend	Control Feature "Steel"
Action 2	1 (US) Corps	Destroy	6 Guards Tank Division
Action 3	1 R IRISH	Defend	Hill 126
Action 4	2 RTR	Constitute a reserve	52 Inf Div
Action 5	1 RHA	Move	Hameln, GE
Action 6	3 GE Recce Bn	Secure	Route Club

ACTION

action-task-id	***-planned-start-date	***-planned-start-time	***-start-qualifier-code	***-planned-end-date	***-planned-end-time	***-end-qualifier-code
1	19940801	120000	No later than	19940807	140000	At
2	19940802	050000	Not before	19940802	020000	No later than
3	19940802	020000	No later than	19940807	140000	At
4	19940802	023000	At	19940807	140000	At
5	19940801	100000	Not before	19940801	180000	No later than
6	19940801	030000	At	19940801	180000	No later than

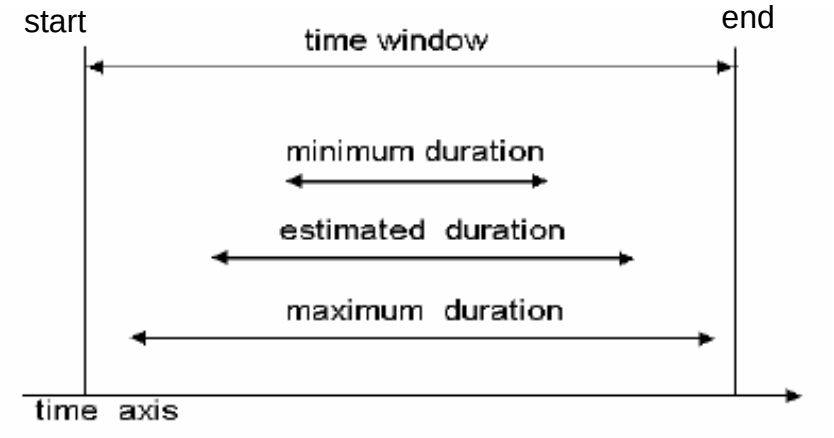
Note: *** stands for "action-task."

ACTION-TASK

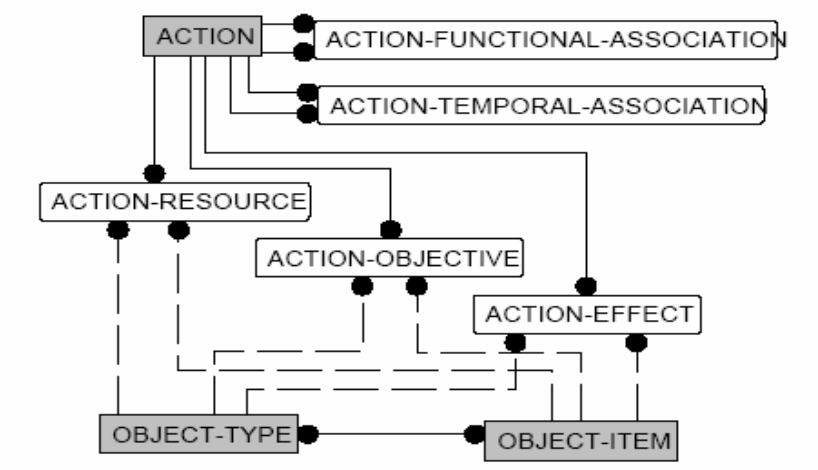
ACTION-TASK Timing

- action-task-minimum-duration
- action-task-estimated-duration
- action-task-maximum-duration
- action-task-planned-start-date
- action-task-planned-start-time
- action-task-start-qualifier-code: *after, as soon as possible, at, before, no later than, not before*
- action-task-planned-end-date
- action-task-planned-end-time
- action-task-end-qualifier-code

Timing Attribute Relationships



Basic ACTION Structure



Role of Objects

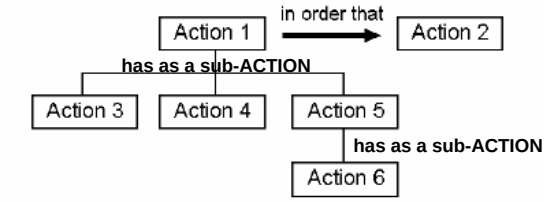
- ACTION-RESOURCE: OBJECT-ITEM or OBJECT-TYPE that is required, requested, allocated, or otherwise used or planned to be used in conducting a specific ACTION
- ACTION-OBJECTIVE: OBJECT-ITEM or OBJECT-TYPE that is the focus of a specific ACTION
  - E.g., helicopters transporting troops to a landing zone
- ACTION-EFFECT: perceived effectiveness of a specific ACTION against a specific item or its type
  - A quantity if the objective is an OBJECT-TYPE
  - A fraction if the objective is an OBJECT-ITEM
  - Can include unintended effects (e.g., collateral damage)

Relating ACTIONs Functionally

- ACTION-FUNCTIONAL-ASSOCIATION
  - One ACTION being dependent on, supporting, or derived from another ACTION
    - Has a provisional sub-ACTION
    - Has as a sub-ACTION
    - In order that
    - In response to
    - Is a modification of
    - Is a prerequisite for
    - Is a template for
    - Is an alternative to
    - Uses as a reference

Relating ACTIONs Functionally

- Complex statements, such as operations orders, can be constructed by relating simple statements in cascading hierarchies

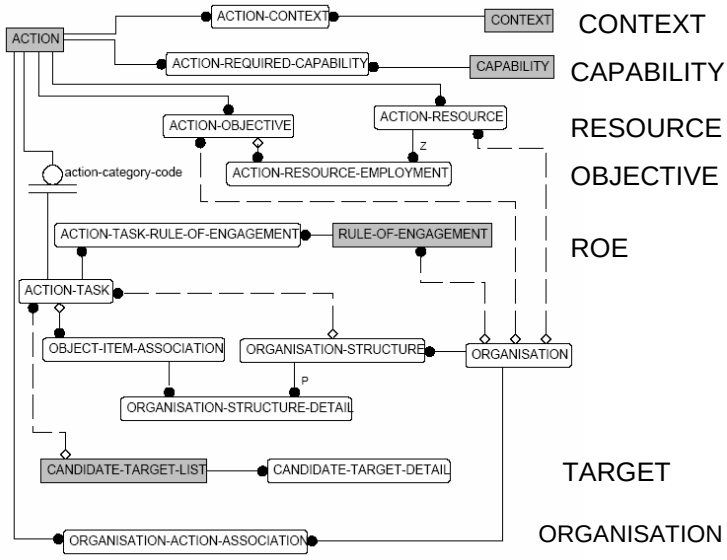


ACTION 2 is the major action supported by ACTION 1. ACTION 1 consists of 4 ACTIONs, three that are directly subordinate to ACTION 1 and one subordinated to ACTION 5.

Relating ACTIONs Temporally

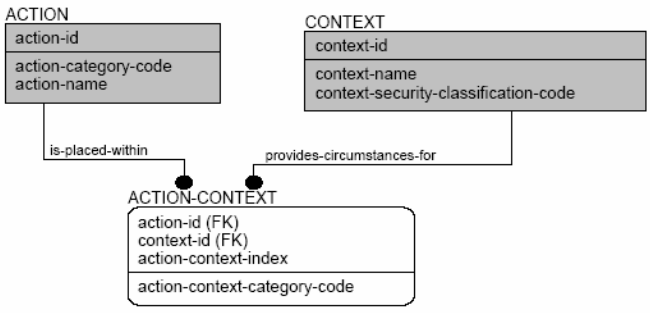
- ACTION-TEMPORAL-ASSOCIATION
  - Assignment of an ACTION (i.e., ACTION-TASK) to be time-dependent for its execution on another ACTION (e.g, ACTION-TASK or ACTION-EVENT)
    - Relative: e.g., starts at the end of, starts during and ends after, starts at the same time and ends after
    - Offset: subject ACTION is to start at some specified time interval before or after a particular reference point in the object task
    - Note: Absolute start and end times are specified in the attributes of ACTION-TASK

Extensions to the ACTION Structure



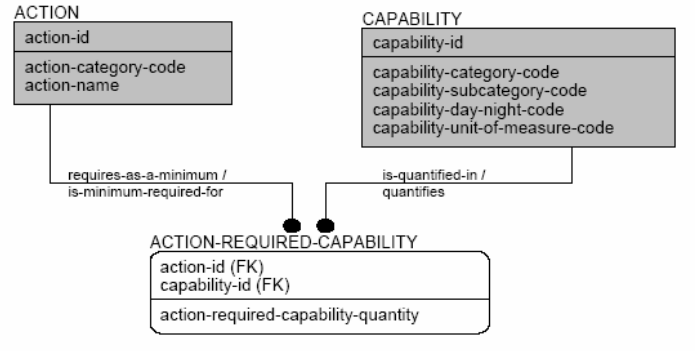
ACTION-CONTEXT

- Links ACTION to CONTEXT to state enabling, constraining, or otherwise relevant conditions on an ACTION



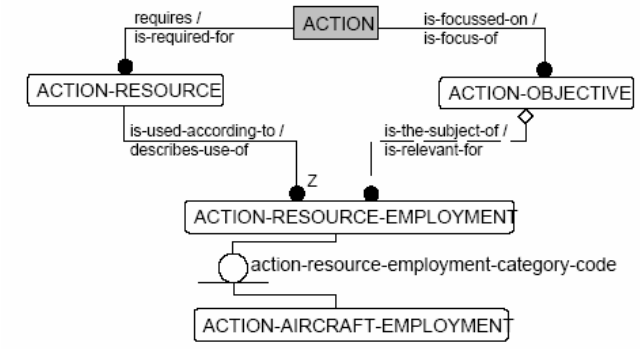
ACTION-CAPABILITY

- For resource employment planning and for in-progress management of resources during the life of an ACTION

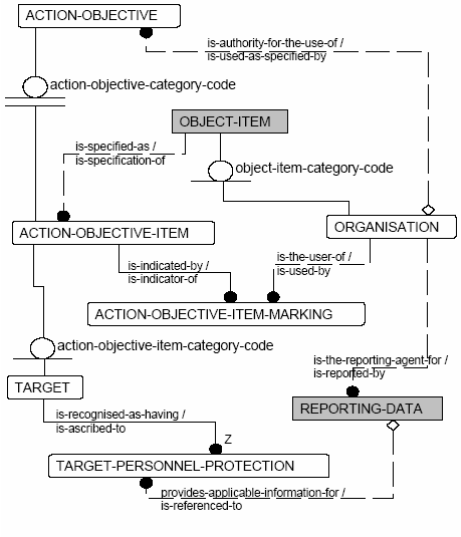


ACTION-RESOURCE-EMPLOYMENT

- Additional guidance in the employment of resources either in relation to a specific objective or independently of it

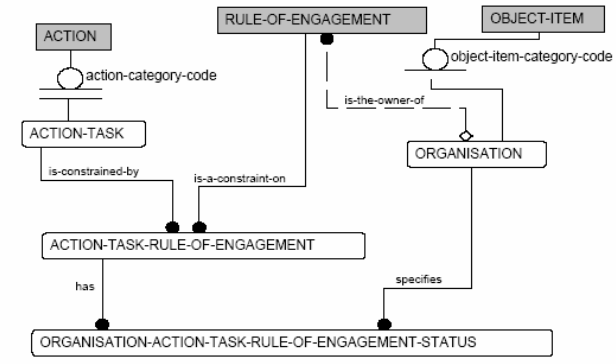


ACTION-OBJECTIVE



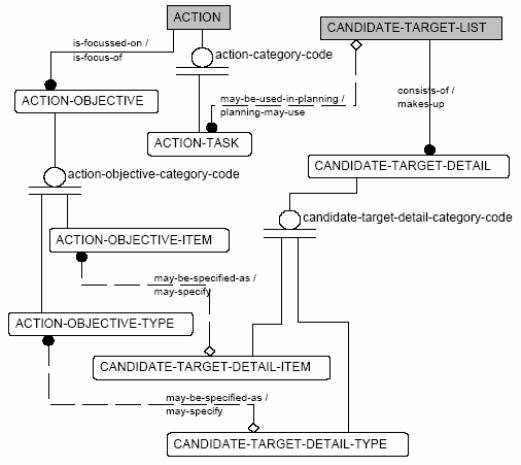
ACTION-TASK-RULE-OF-ENGAGEMENT

- List of rules, authorizing organization, and status of request (application, cancellation, authorization)



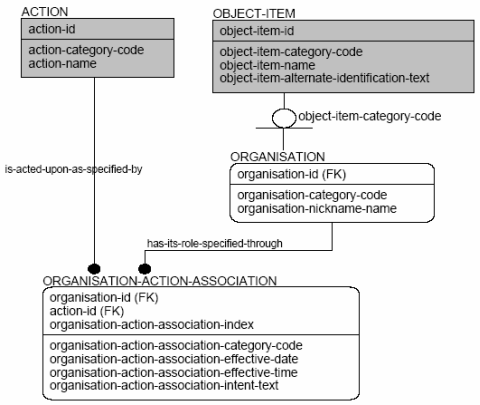
CANDIDATE-TARGET-LIST

- Links candidate targets to operations planning



ORGANISATION-ACTION-ASSOCIATION

- Identifies the kind of responsibility an ORGANISATION may have for an ACTION (initiates, plans, disseminates, oversees, etc.)



C2IEDM Application Initiatives

Various C2IEDM Initiatives

- Interoperability, Data Control and Battlespace Visualization
- MOOTW FAST Toolbox Data Interchange
- Common Maneuver Network (CMN) and Mobility Common Operational Picture (M-COP)
- C4I-M&S Reference Object Model (CROM)
- Coalition Secure Management and Operations System (COSMOS)
- Autonomous Vehicle Control Language (AVCL)
- Schema and Ontology Development Efforts

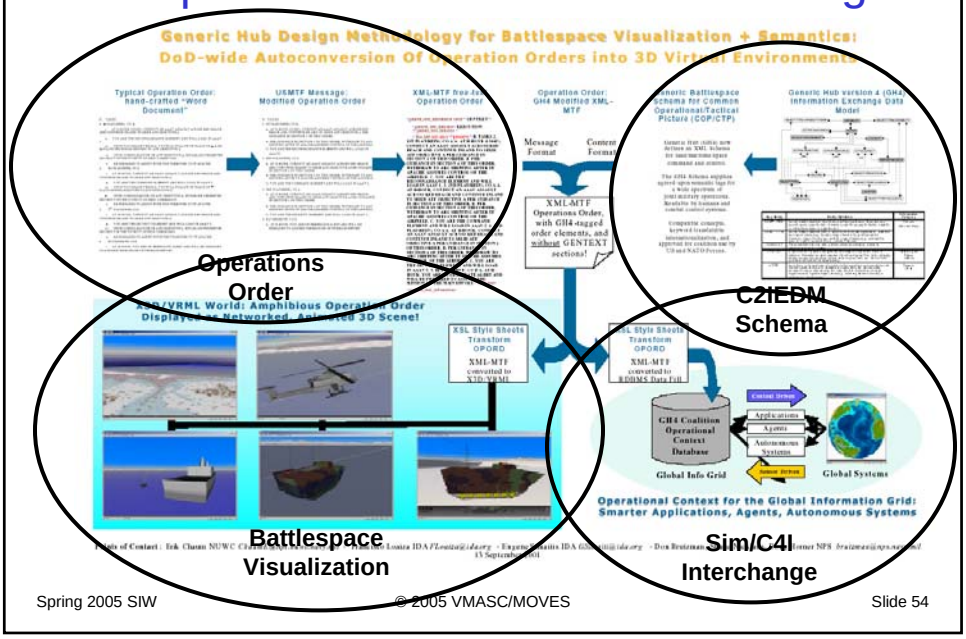
Scenario Authoring and Visualization for Advanced Graphical Environments

- Maj Shane Nicklaus, USMC, *Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE),* Master's Thesis, September 2001

  http://MovesInstitute.org/Theses/ShaneNicklaus.pdf

- "This research presents an integrated Web access and 3D visualization strategy for Department of Defense (DOD) tactical messaging and operation orders using the Generic Hub data model and the Extensible Markup Language (XML)."

Operations Order Data Interchange



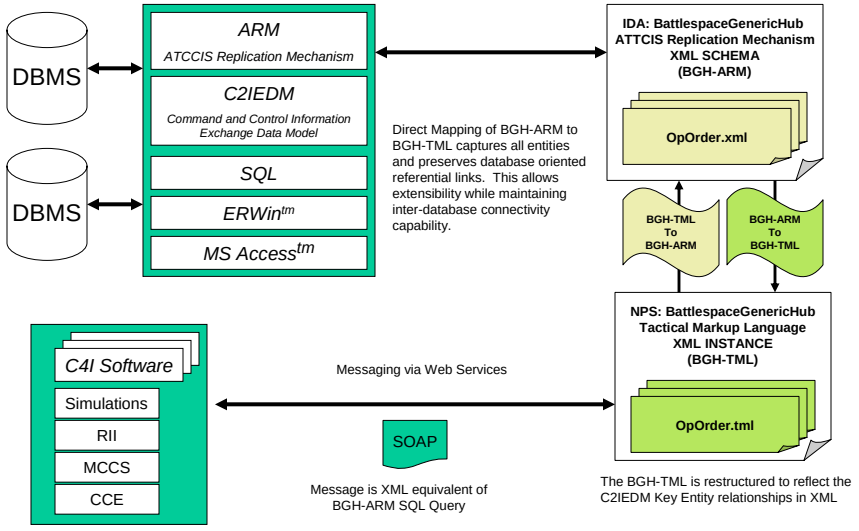
Interoperability, Data Control and Battlespace Visualization

- Capt James Neushul, USMC, *Interoperability, Data Control and Battlespace Visualization Using XML, XSLT, and X3D,* Master's Thesis, September 2003

  http://MovesInstitute.org/Theses/NeushulThesis.pdf

- "The application of structured data methodologies using the Extensible Markup Language (XML) allows organizations and systems to exchange and process battlespace information cooperatively."

Battlespace Generic Hub (BGH) – XML Schema Extensions



MOOTW FAST* Toolbox Data Interchange

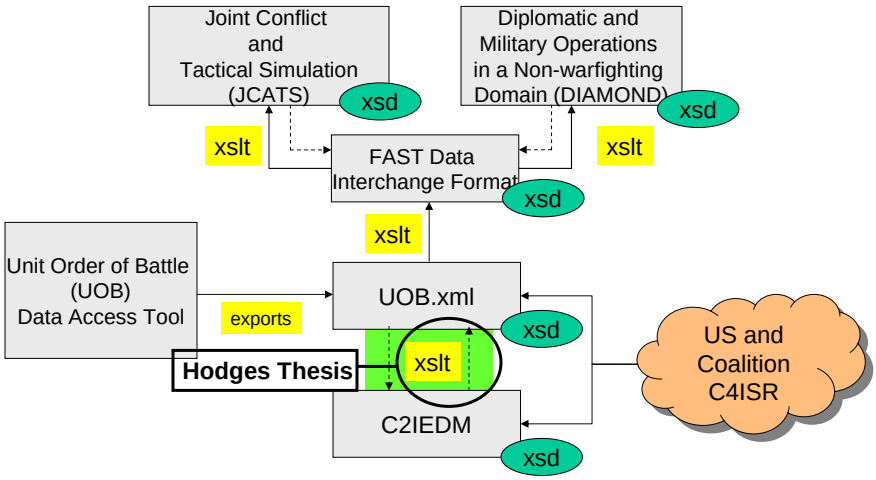
- Capt Glenn Hodges, USA, *Designing a Common Interchange Format for Unit Data using the Command and Control Information Exchange Data Model (C2IEDM) and XSLT,* Master's Thesis, September 2003

  http://www.movesinstitute.org/Theses/Hodgesthesis.pdf

- "Using a common data representation like C2IEDM coupled with the power of XML and XSLT, unit information can be transformed and interchanged between applications."

*Flexible Asymmetric Simulation Technologies

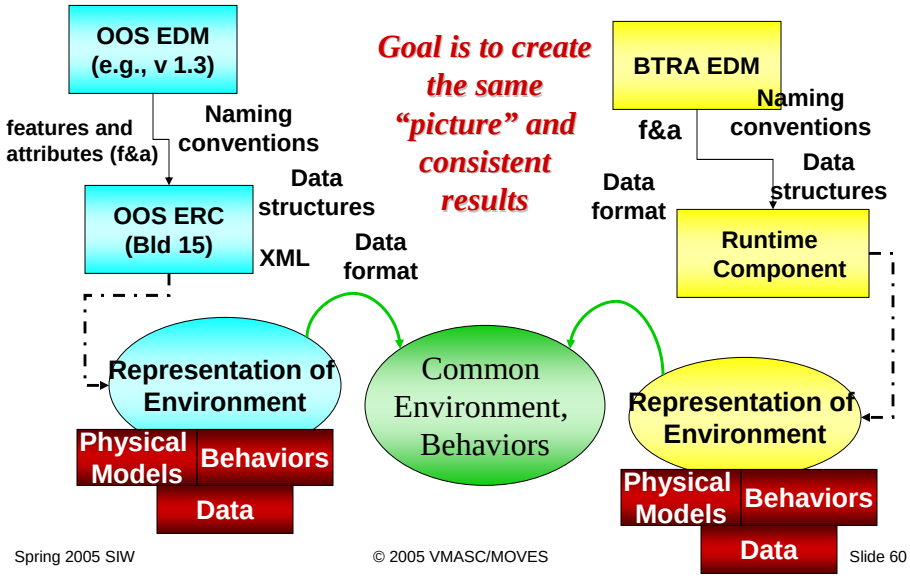
Unit Data Interchange



Common Maneuver Network

- Common data representations across C4I systems and M&S (embedded M&S in FCS)
  - Battlespace Terrain Reasoning and Awareness (BTRA)
  - OneSAF Objective System (OOS)
- Various maneuver network representations under investigation
  - C2IEDM
  - Battle Management Language (BML)
  - Military Scenario Definition Language (MSDL)
  - Geography Markup Language (GML)

Common Maneuver Networks



C4I-M&S Reference Object Model (CROM)

- Goal: Standard reference for simulation interoperability and alignment with C4I
- Alignment studies
  - Simulation representations are not aligned with tactical data models
  - Simulation community has no standard for interoperability with C4I systems
- Created initial Army C4I Object Model from C2IEDM aligned with Joint Common Data Base Data Model
  - Converted from LC2IEDM to Unified Modeling Language (UML)
  - Added JDM table entities for materiel and organization
  - Upgraded to C2IEDM v6.1 (CROM Baseline Version 1.1)
- Follow-on Work: Incorporate new and updated Battle Management Language (BML) hierarchies into CROM baseline (support BML mapping to C2IEDM)

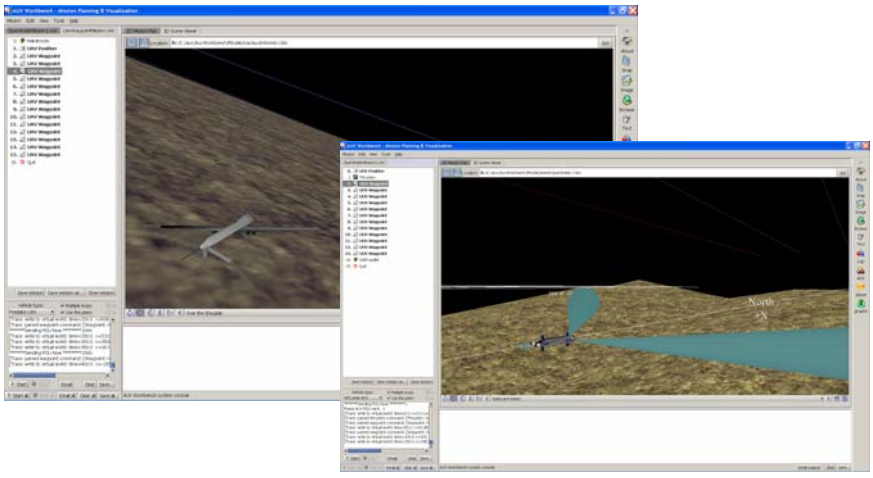
COSMOS ACTD

- Coalition Secure Management and Operations System (COSMOS) Advanced Concept Technology Demonstration (ACTD), 2005-2009
  - "Enable rapid information exchange among MIP-compliant coalition C2 applications using the MIP specifications and procedures."
- Various initiatives planned:
  - C2IEDM-enabled data interchange under role-based access controls
  - C2IEDM for description of roles
  - C2IEDM for description of the network
  - C2IEDM-based tactical chat (controlled vocabulary)

Autonomous Vehicle Control Language (AVCL)

- Autonomous Vehicle Control Language (AVCL)
  - XML language for arbitrary autonomous vehicle mission definition, inter-vehicle communication and mission-data storage
  - CDR Duane Davis, USN, PhD dissertation, in progress – designing the language for compatibility with JC3IEDM
  - May be useful to Battle Management Language (BML) development in defining a control language for robotic forces
- Adapt the Battle Management Language (BML) to context of Naval operations
  - Work proposed; not yet started
  - Scenarios: Anti-Submarine Warfare (ASW), SSBN / Special Operations Forces

AVCL in the Autonomous and Unmanned Vehicle (AUV) Workbench



Schema and Ontology Development Efforts

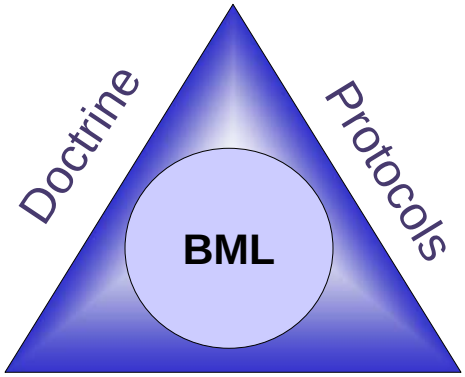
- NUWC/IDA: Physical and Logical representations of the C2IEDM in XML Schema posted to DoD Metadata Repository
- NATO M&S: Expressing an Object-Oriented representation of the C2IEDM in XML Schema
- IDA and others: Expressing C2IEDM data concepts and relationships in Web Ontology Language (OWL)
  - Future work to express business rules in OWL and Semantic Web Rule Language (SWRL)
- Domain extensions: Chemical, Biological, Radiological, and Nuclear (CBRN)

What Is Battle Management Language (BML)?

- BML is the unambiguous language used to:
  - Command and control forces and equipment conducting military operations, and
  - To provide for situational awareness and a shared, common operational picture.

Commander's Intent becomes Data!

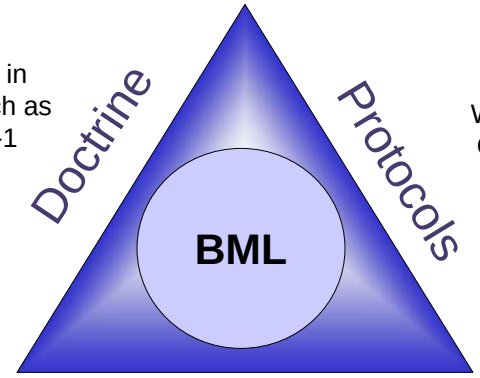
BML Views



Representation

BML Views

Terms root in Doctrine, such as
FM 101-5-1
AAP-6
…

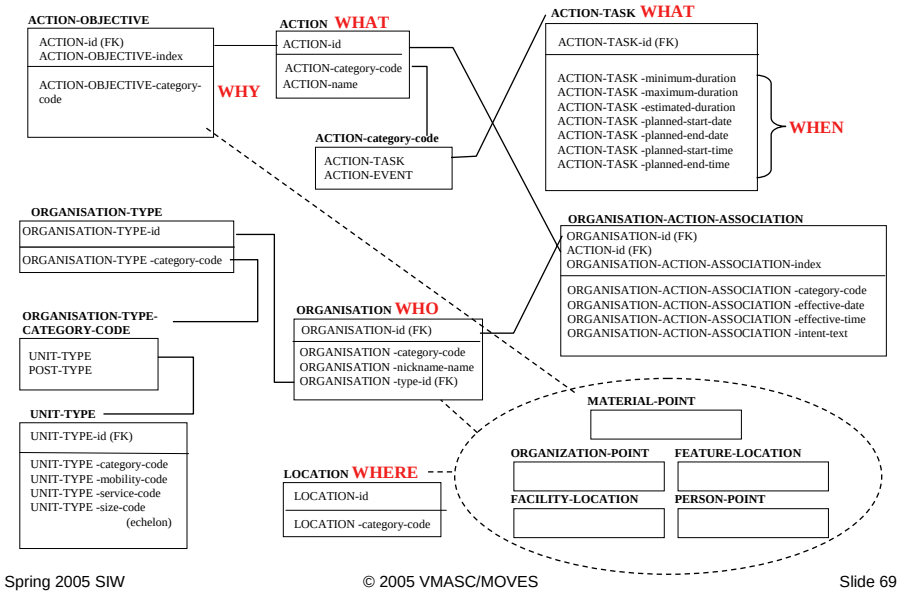


XML
Web Services/
Grid Services

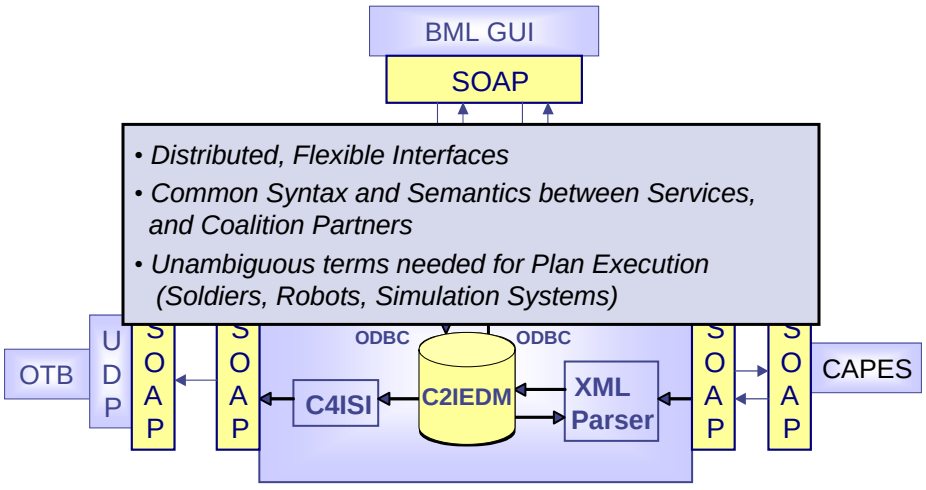
Representation

Command & Control
Information Exchange
Data Model

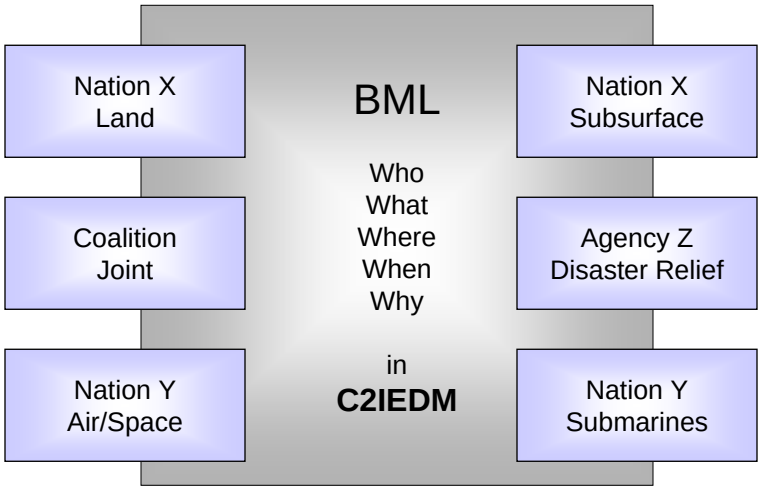
5 Ws in C2IEDM



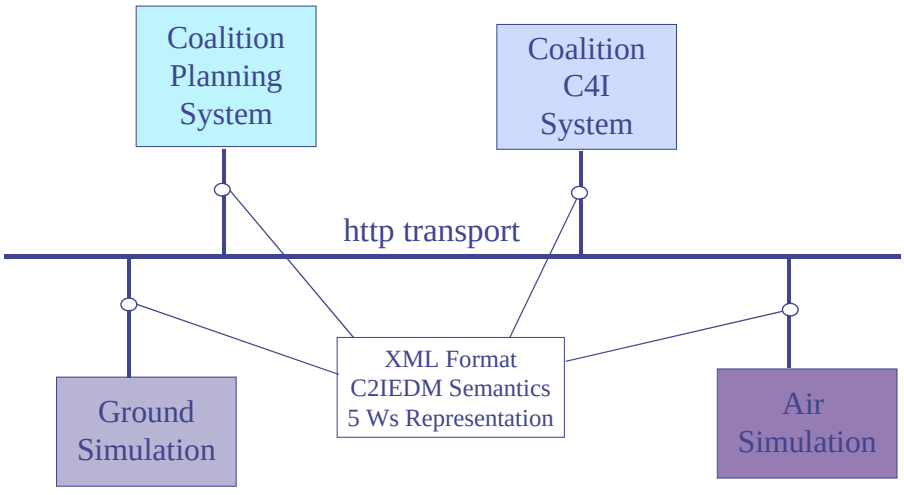
XBML Testbed Distributed Interfaces



Joint BML Implementation Concept: Extend the C2IEDM



Using XBML in Coalition Operations



Data Engineering

Components of Data Engineering

Data Administration

- Managing the information exchange needs incl. source, format, context of validity, fidelity, and credibility

Data Alignment

- Ensuring that data to be exchanged exist in all participating systems

Data Management

- Planning, organizing and managing of data, define and standardize the meaning of data as of their relations

Data Transformation

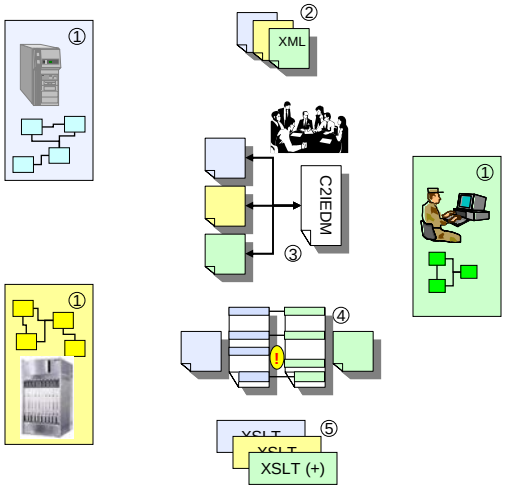
- Technical process of mapping information elements to each other (often implemented in gateways and interfaces)

Web-based Standards supporting Data Engineering

- XML as the common syntax and format of all components
- Data source registers data description following the idea of Universal description, discovery, and integration registries (UDDI)
- Mapping of data will be management of tag sets
- After data management using tag set, data alignment becomes one-to-one comparison
- Data management can lead to XSLT schema for data translation

Potential for Automation of Data Administration, Data Alignment and Data Translation based on Data Management

Bringing in all together – XML Data Mediation Services based on the C2IEDM



(1) Data Modeling and Data Documentation
- XML Document

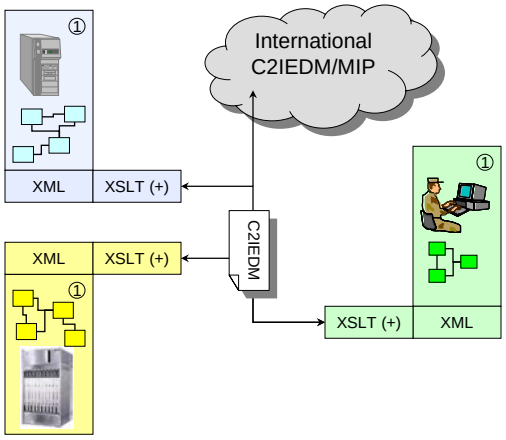
(2) Data Administration

(3) Data Management
- Mapping to C2IEDM
- Extending C2IEDM
- Enhancing C2IEDM

(4) Data Alignment

(5) Data Transformation
- Generate XSLT (+)

Bringing in all together – XML Data Mediation Services based on the C2IEDM



(1) Data Modeling and Data Documentation
- XML Document

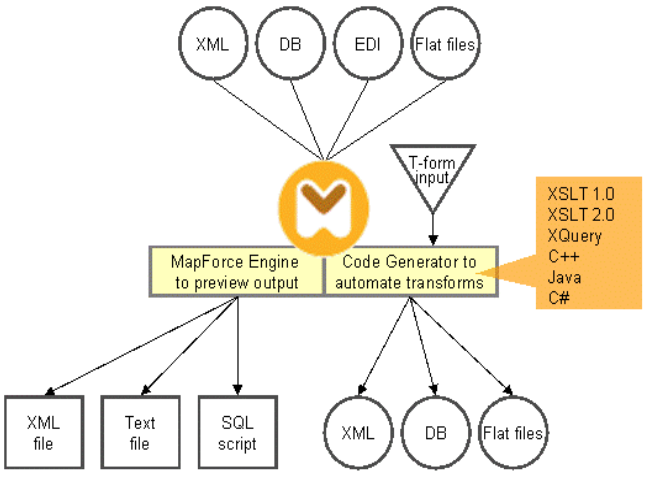
(2) Data Administration

(3) Data Management
- Mapping to C2IEDM
- Extending C2IEDM
- Enhancing C2IEDM

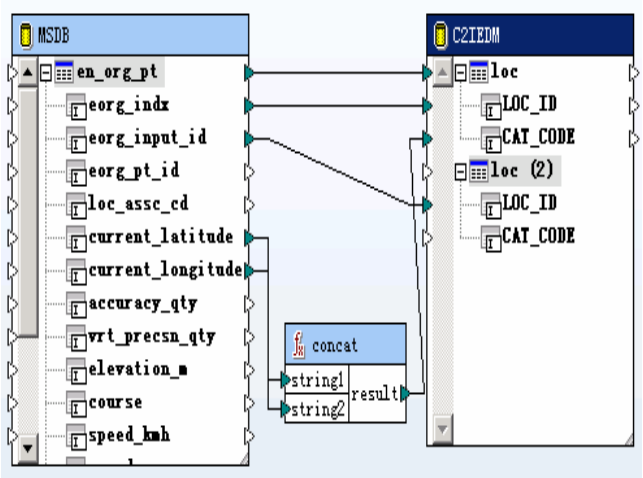
(4) Data Alignment

(5) Data Transformation
- Generate XSLT (+)

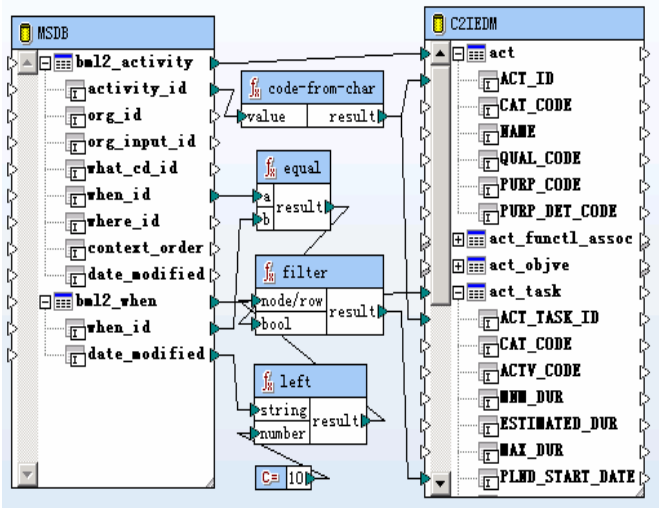
Functionality of MapForce



Mapping Example I



Mapping Example II



Summary

- C2IEDM (and in the future JC3IEDM) is applicable for Common Reference Model
- Commercial tool sets available
  - Common documentation is required
  - Common configuration of solutions is the ultimate objective (configure mapping, not program it)
- More information during the workshop
  - 05S-SIW-007 Tolk/Blais
  - 05S-SIW-019 Tolk/Diallo/Dupigny/Sun/Turnitsa
  - 05S-SIW-068 Dobbs/DeMasi/Ritchie/Sudnikovich